



# Advanced Transportation Hub Efficiency using Novel Analysis (ATHENA)

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National Renewable Energy Laboratory (NREL)  
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DOE Vehicle Technologies Program  
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Project ID # ti094

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# Overview

## Primary Partners



## Timeline

Project start date	10/01/2018
Project end date	09/30/2021
Percent complete	50%

## Barriers

- Airport passenger **volumes are expected to double in the next 20 years** with similar growth in air cargo volumes
- The **DFW region** is one of the **nation's fastest growing metropolitan regions** currently in non-attainment for Ozone and NOx
- New **disruptive transportation technologies** (electric, connectivity, automation) and new **transportation business models** (TNCs) being introduced
- **Resiliency** in the face of disruptions due to weather, system failures, and unforeseen events

Project Lead: Caleb Phillips (NREL)

## Budget

Total Project funding	6,000,000
DOE funding	5,000,000
Cost sharing	1,000,000

	Total DOE	NREL	ORNL
FY19 and FY20 YTD	\$2.5M	\$1.6M	\$900K
Remaining	\$2.5M	\$1.4M	\$1.1M

# Project Objectives

## Objectives

- Utilize the DOE's world-class **high-performance computing** (HPC) resources
  - Expertise in **optimization, modeling, data sciences, and transportation systems**
1. To drive effective decision-making around advanced mobility technologies
  2. Identify insights that will enable long-term gains in efficiency and productivity
  3. Develop common metrics and methodology for DFW that can be applied to other ports.

## VTO Technology Integration Goals

- *National security*: transportation energy diversity
- *Economic growth*: ports are major economic drivers in their regions
- *Affordability for business and consumers*: electrification and efficient mobility advancements
- *Reliability/resiliency*: strategies for demand growth and new mobility options.

# Project Objectives: Impact

- The application of operational models to support near-term needs in planning for **shuttle fleet electrification** and **curb-front terminal congestion**
- Enable DFW to demonstrate a **50% reduction in ground transportation energy use** for the airport and its connected transportation infrastructure by 2045
  - Increasing systemwide affordability, emissions reduction, and improving convenience and efficiency at the connected regional transportation system
  - Adoption of future technologies
- Demonstrate a decoupling between population growth and energy use
- Process that is replicable to other regional hubs



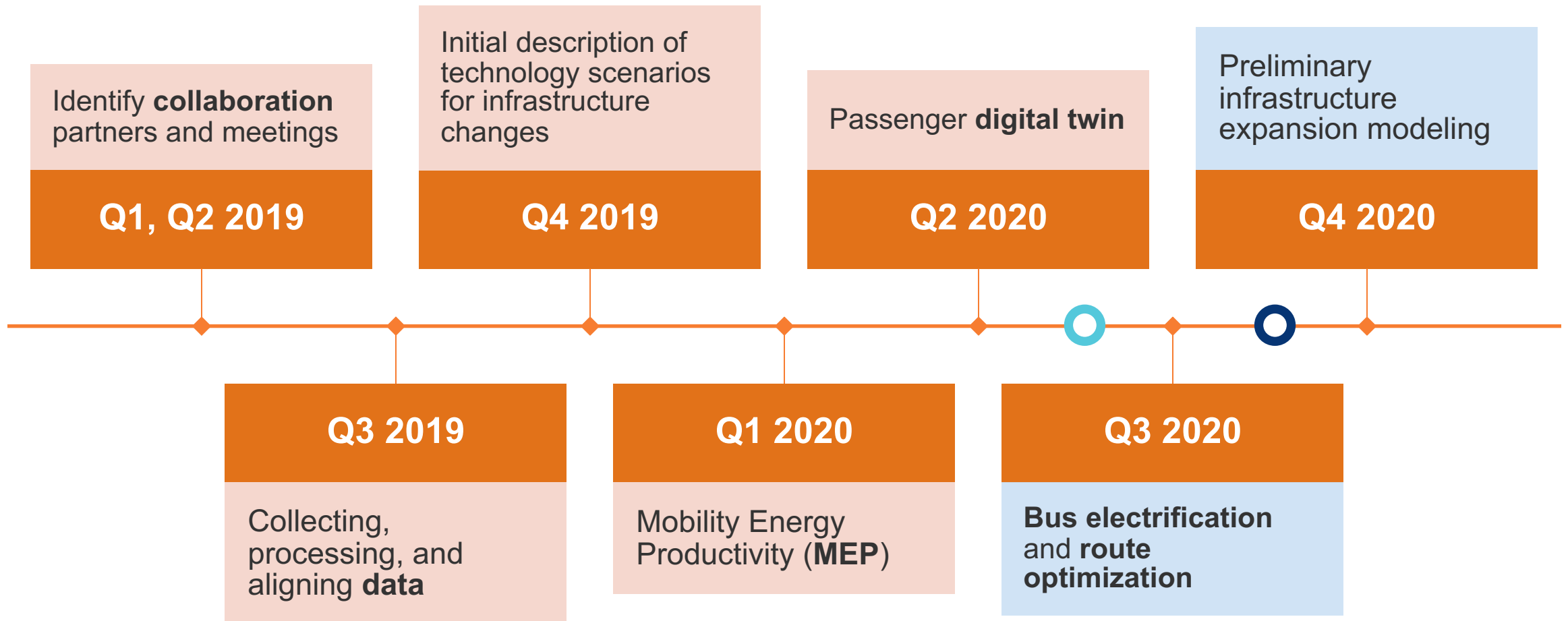
# Milestones

Q1 2019	Kickoff meeting for project with key team members and institutions	Done
Q2 2019	First quarterly meetings with advisory panel	Done
Q3 2019	Relevant operational data for DFW gathered, aligned, and stored for analysis	Done
Q4 2019	Initial description of technology scenarios and key model parameters for potential infrastructure changes for DFW	Done
Q1 2020	Results from airport-Specific <i>Mobility Energy Productivity</i> Analysis for DFW	Done
Q2 2020	Results from <i>Demand Prediction</i> and <i>Congestion Modeling</i>	Done
Q3 2020	Results from <i>Bus Electrification</i> and <i>Route Optimization</i>	In progress
Q4 2020	Preliminary results from <i>Infrastructure Expansion Modeling</i>	In progress
<b>08-2020</b>	<b>Go/No-go</b> based on 2020 Q1, Q2, and Q3	In progress

Any proposed future work is subject to change based on funding levels.

# Approach

○ We are here    ● Go/No-Go



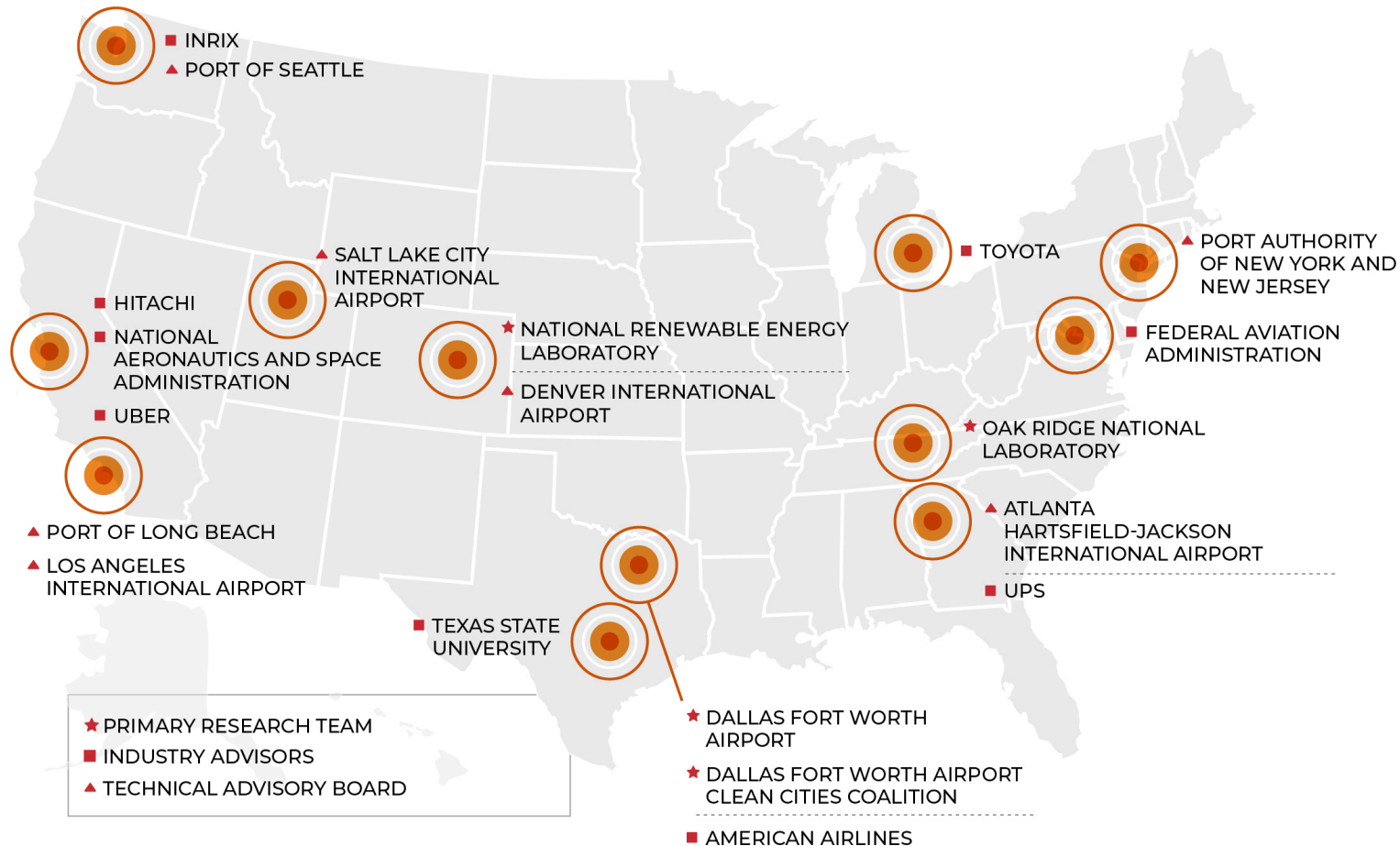
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# Project Accomplishments and Progress

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# Collaboration



Over 20 different **Port Advisors** and **Industry Advisors** supporting ATHENA goals and research objectives.

## Accomplishments

- October 2018: ATHENA technical kickoff meeting
- November 2018: Partner meeting
- November 2019: Year 2 kickoff meeting
- June 2019: Stakeholder meeting
- January 2020: Stakeholder meeting

*CRITICAL: Advisors help ensure broad applicability and generalization of ATHENA outcomes*



# DFW Operational Data



Locate, transfer, and organize **35 critical data sources**.

StreamSets ETL, Selenium, Postgres DB, and Google drive

**Gap analysis** identified 5 missing data sets

Data-sharing partnerships and investments in digital and sensing infrastructure could result in more **complete and accurate models** of current airport operations

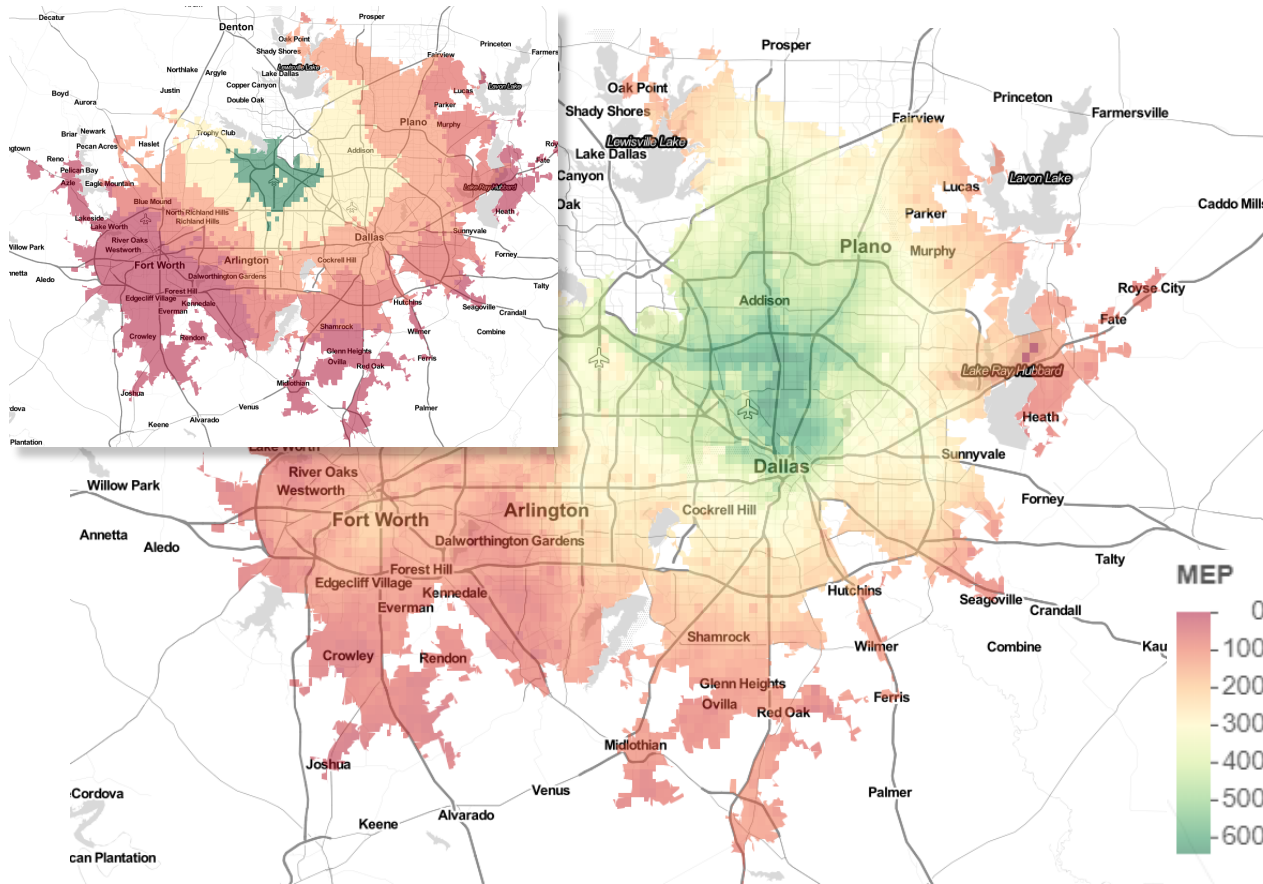
*Data sets and gap analysis, along with our current research, identify the most critical data needed to build operational models at airports.*

# Mobility Energy Productivity (MEP) Metric

Quantifies the effectiveness of mobility in a region accounting for energy and affordability.

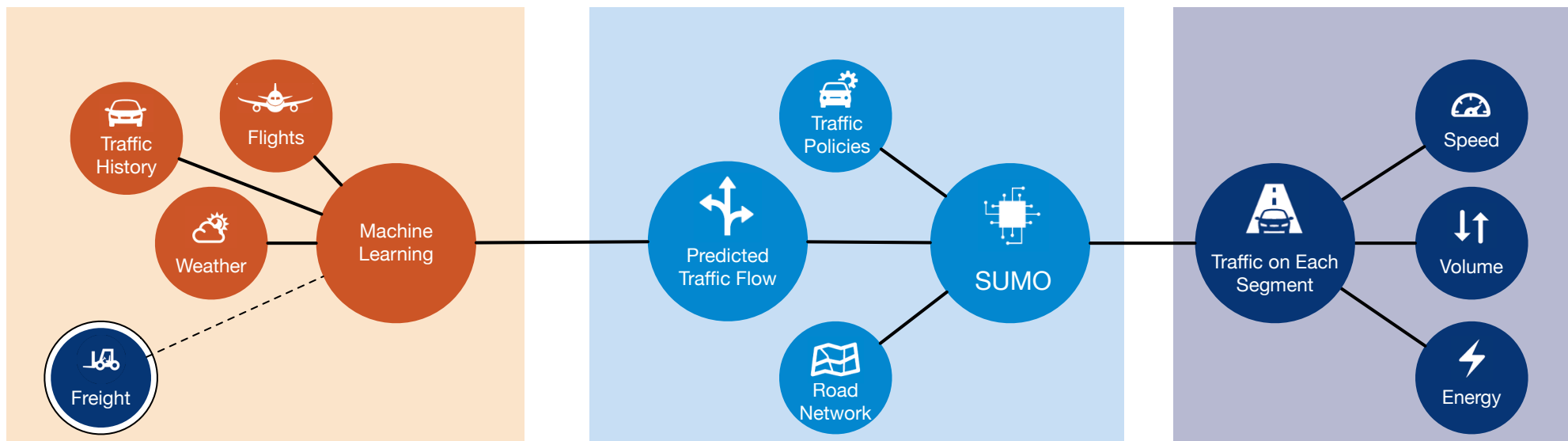
Higher MEP score (green) represents greater access to a variety of opportunities using a larger set of modes in a time-, cost-, and energy-efficient manner.

An **airport-specific MEP** quantifies the ease of accessing DFW airport from various locations in the DFW region.



*MEP Metric provides a foundation for comparing improvements in transportation infrastructure that lead to increased ease of access of the DFW airport or other locations around the DFW region.*

# Digital Twin Operation Model



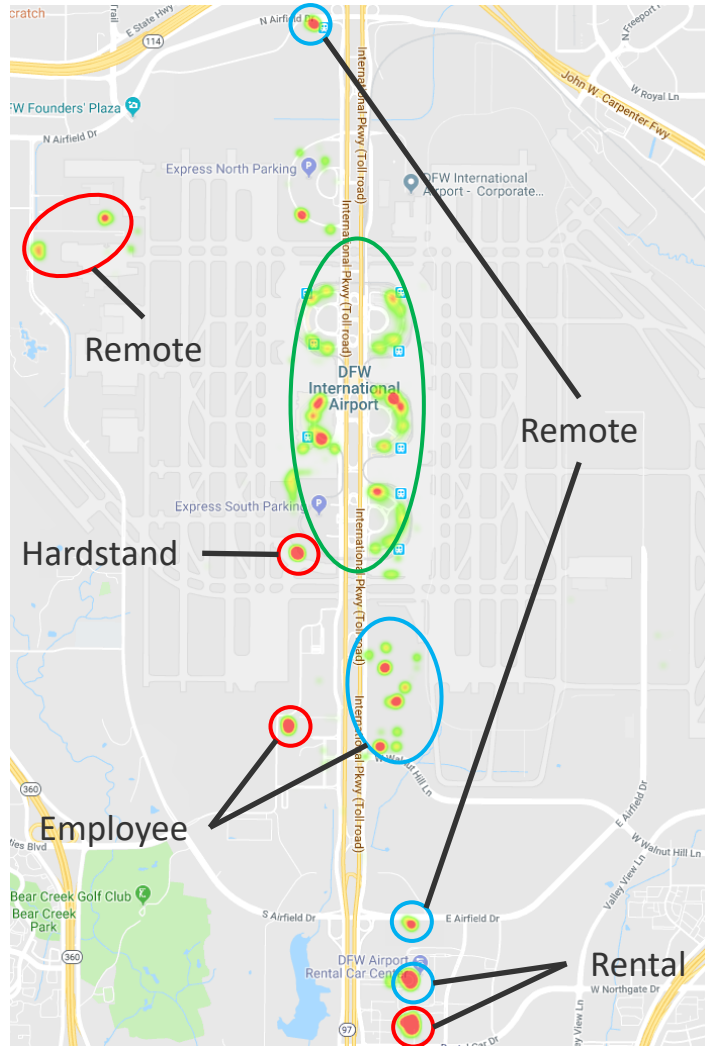
**Machine-Learning** models effectively predict traffic flow from historic data streams with, trained and tuned on NREL's **HPC**.

**Traffic simulation** with a road network and a set of policies. Simulations on NREL's **HPC**.

Detailed output of various characteristics

*Using this model, DFW can forecast near-term traffic impacts of the Central Terminal Area (CTA) in real time, as well as simulate novel scenarios to explore potential policy and infrastructure changes.*

# Bus electrification

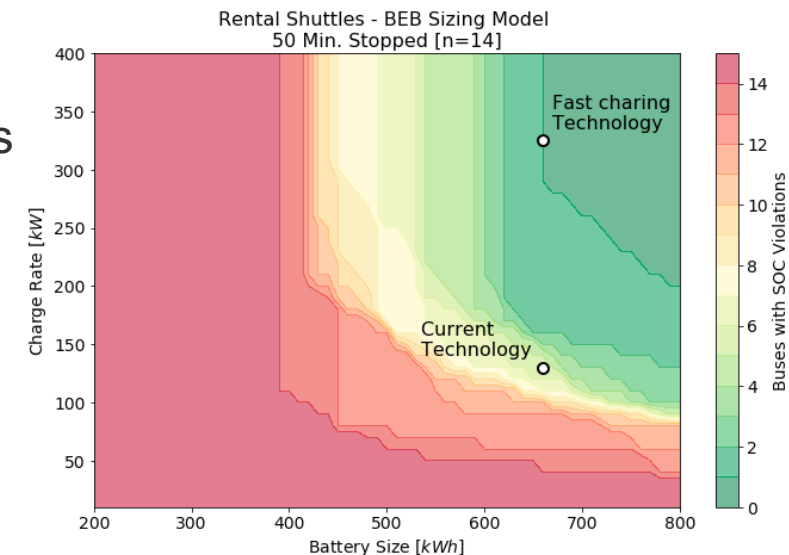


## Data acquisition and duty cycle analysis

- 173K miles, 1 Hz GPS and CAN data
- Rental car, employee and remote parking and hard-stand terminal shuttles
- Detailed duty cycle characterization
- Data used in bus route optimization

## EV powertrain simulations – estimate of energy storage for DFW shuttle applications

**Dwell-time Hotspot Analysis -**  
visualization of frequent stop locations to identify potential locations for EV chargers.



*50% - 100% of Rental Car shuttles could be electrified with current battery and charger technologies.*

# Bus Route Optimization

## Objective

Reduce **energy consumption** subject to:

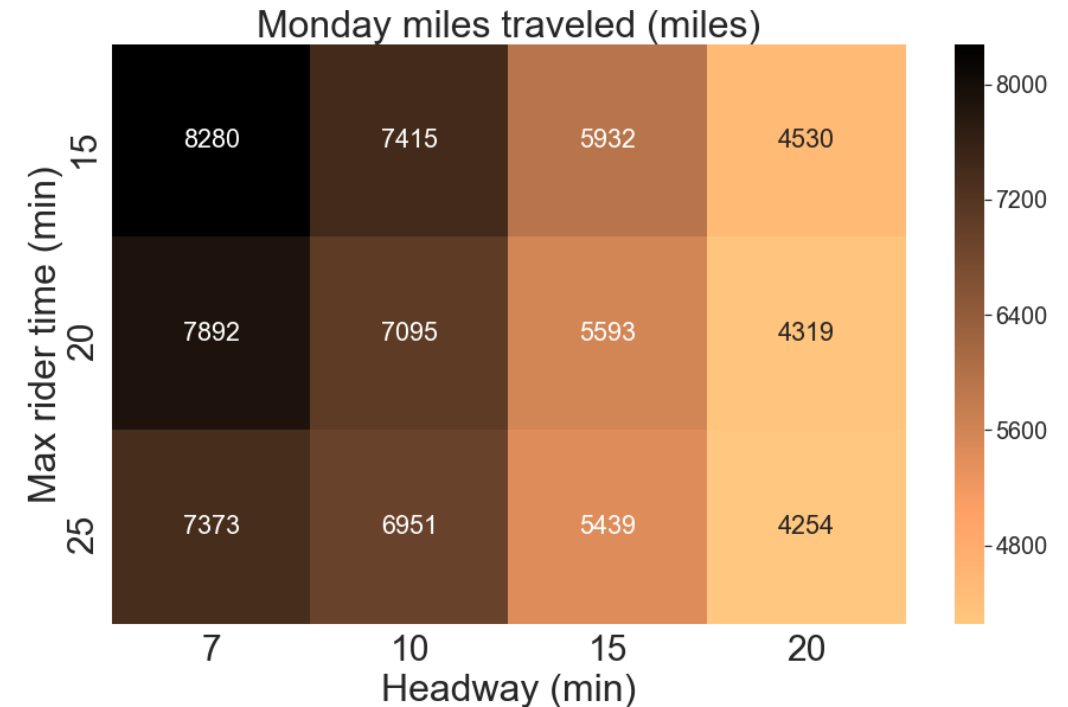
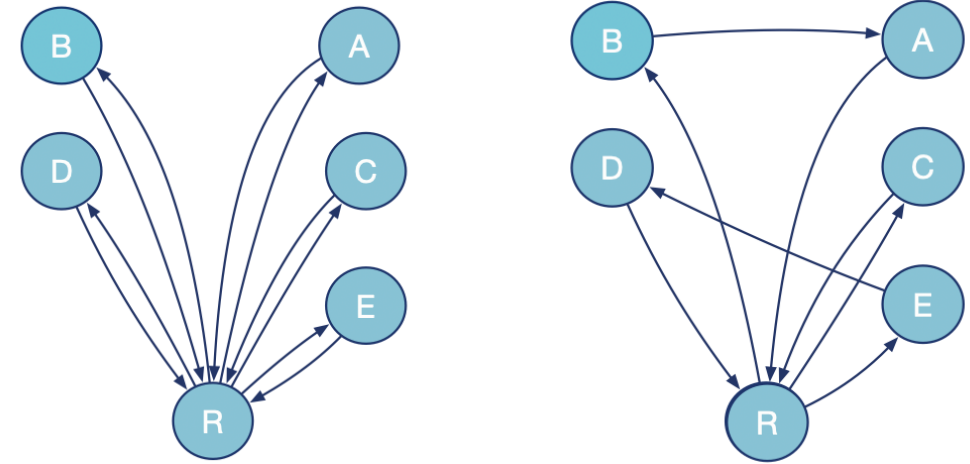
- Reducing passenger **wait times**
- Minimizing unused bus **capacity**.

Optimization performed on NREL's **HPC** and final solutions are validated in parallel by a discrete event simulator.

**Headway** and **maximum ride time** are directly related to **energy use** and **emissions**.

*A 30% efficiency gain is available with some customer impacts; 60% possible overall.\**

*\*preliminary results*



Collaboration and Coordination,  
Overall Market Impact,  
and Summary

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# Collaboration and Coordination

## Primary collaborators

Project partners, data sharing,  
weekly or bimonthly meetings



## Advisors

Quarterly meetings on progress

**Ports:** Seattle, Long Beach, Port Authority of New York New Jersey (PANYNJ)

**Airports:** LAX, Salt Lake, Denver, Atlanta, DFW

**Industry Advisors:** Uber, Hitachi, Texas State University, American Airlines, UPS, FAA, Toyota, INRIX, National Aeronautics and Space Administration.

## Data partners

Data sharing and ad hoc support

DFW, American Airlines, UPS, INRIX,  
North Central Texas Council of  
Governments (NCTCOG)





# Overall Market Impact

## Achievements

- Created a consortium around mobility at ports
- Gathered and identified key data sets for operational models
- Created a metric, MEP, for understanding mobility and energy
- Operational model of the DFW airport on NREL's HPC
- Evaluated bus electrification
- Bus route optimization using NREL's HPC



## Upcoming

- Explore congestion policies at the Central Terminal Area (CTA)
- Mode-choice and Agent-Based Model (ABM) for future demand
- Optimization for planning for infrastructure expansion

*Any proposed future work is subject to change based on funding levels.*

# Summary

<b>Objectives</b>	Use world-class HPC and cutting-edge data science to optimize energy productivity at major transportation hubs
<b>Approach</b>	Build a consortium around mobility
	Gather necessary data and identify gaps
	Build an operational model, evaluate electrification and route optimization, create mobility metrics, long-term planning
<b>Collaborators</b>	Partners, advisors, and data providers
<b>Accomplishments</b>	20 advisors and 3 partners on the project
	Data collected and gaps identified
	Mobility Energy Productivity (MEP)
	Operational data-driven model
	Bus electrification and route optimization

# Thank You

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**[www.nrel.gov](http://www.nrel.gov)**

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# Reviewer-Only Slides

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# Publications

**Sustainable and Emerging Transportation Technology 2020:** Ravulaparthi, S., Park, B., Hilliard, M., & Phillips, C. (to be presented Sept 2020) *Copula-based joint discrete-continuous model of dwell-time and mode choice preferences of departing passengers at Dallas Fort Worth Airport..*

**TRB Annual Meeting:** Monte Lunacek, Lindy Williams, Joseph Severino, Karen Ficenec, Juliette Ugirumurera, Matthew Eash, Yanbo Ge, Caleb Phillips. *A Data-driven Operational Model for Traffic at Dallas Fort-Worth International Airport.* 99th TRB Annual Meeting. January 12-16, 2020.

**TRB Annual Meeting:** H M Abdul Aziz, Xiaodan Xu, Yanbo Ge, Michael Hillard, Caleb Phillips. *Modeling Travel Mode Choices Near Transportation Hubs: The Case of Dallas-Fort Worth Airport using Revealed Survey Data.* 99th TRB Annual Meeting. January 12-16, 2020.

**INFORMS 2019:** Michael Hillard et al. *New Data Visualizations Support Analysis of Vehicle Traffic at DFW Airport.* INFORMS. October 20-23, 2019.